ORIGINAL RESEARCH

To determine the morphometric and volumetric measurements of the paranasal sinuses in the Indian population

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ABSTRACT
Aim: To determine the morphometric and volumetric measurements of the paranasal sinuses in the Indian population.**Material and methods:**This prospective cross-sectional research aimed to quantify structural variations of paranasal sinuses in individuals receiving CT scan examination. 210 participants took part in this research. We determined the volume of CT in each region by multiplying the area by the slice thickness. We used the Cavalieri principle to determine the total volume of regions by averaging the standard deviations of all slice volumes. **Results:**The mean volumes of the frontal sinus, maxillary sinus, ethmoid sinus, and sphenoid sinus were 8.41±1.34 cm3, 19.01±2.46 cm3, 7.34±1.04 cm3, and 7.11±1.21 cm3, respectively. There was a statistically significant difference in the volumes of paranasal sinuses across genders ($P<0.05$). The average capacity of paranasal sinuses in older persons gradually decreases. Patients with a straight nasal septum did not exhibit any statistically significant change in paranasal sinus volumes. The deviated nasal septum affected the size of certain paranasal sinuses. A statistically significant correlation has been shown in our investigation between the average volumes of paranasal sinuses and the existence of deviated nasal septum. **Conclusion:** We concluded that the computed tomography is a dependable technique for assessing various morphometric measurements and volumetric analysis of paranasal sinuses.
Keywords: Morphometric, Volumetric, Paranasal Sinuses,IndianPopulation

INTRODUCTION

Forensic odontology has developed in conjunction with technology advancements and data collection methods during the course of civilization [1]. Forensic odontology is now widely acknowledged as an essential field in legal and medical matters for verifying the identity of dead individuals. Forensic odontology expertise is utilized to assess injuries to the jaws, oral tissues, and teeth caused by different events, determine if a suspect is a predator by analyzing bite marks, and identify individuals using dental remains in cases of large-scale disasters[2]. The skull is often the only part of the skeleton available for forensic analysis as it is commonly well-preserved after death. There has been a significant rise in criminal cases, especially those related to murder and the burning of bodies. When facial features are completely distorted, identifying the deceased becomes a challenge for forensic experts. Identification in these instances relies on factors such as age, gender, race, size, injury marks, distinguishing traits such polydactyly, calluses from ancient fractures, or the presence of an additional rib. While these traits are helpful in identifying a dead individual, they may not be entirely effective in identifying based on a human skull[3]. Identifying an individual's gender is crucial in forensic investigations, especially in cases involving fragmented and deteriorated remains, such as those found in natural disasters, mass casualties, or crime scenes. Sexual identity can be determined by examining bodily parts such as the skull, pelvis, long bones, foramen magnum, sella turcica, mandibular ramus, and paranasal sinuses. Identifying the gender of these bones is challenging due to their common state of being fractured or fragmented. Denser bones such as the maxilla are often utilized because they are commonly extracted intact [4,5]. Diverse populations exhibit variations in the shape and dimensions of their maxillary sinuses between males and females, as indicated by extensive research [6]. Loss of teeth in adulthood can cause changes in the size of the maxillary sinus. Also, both genders undergo a decline in maxillary sinus size after the peak of their growth due of the depletion of nutrients in the bone [7]. The frontal sinus is an important craniometric feature in forensic identification due to its irregular shape. Females were found to have smaller frontal sinuses than men in research investigating the correlation between the frontal sinus and gender [8,9]. Radiography is used in forensic odontology when the corpse is burned, damaged, or fractured. Radiographic tests are often used to ascertain age, gender, the precise position of gunshots and the resulting wound tracks, and to assess the fragmented remains of the skull and other body parts. Computed Tomography (CT) is used for less intrusive postmortem treatments such as virtopsies, since it can display anatomical features in three dimensions. CBCT offers many functional and technical benefits compared to conventional CT. CBCT pictures exhibit less metallic artifacts compared to CT images. Moreover, CBCT image reconstruction is speedier and decreases radiation exposure by 96% compared to standard CT [11]. CBCT has been demonstrated to be helpful in detecting gender using a range of anatomical characteristics in several research [12]

MATERIALS AND METHODS

This prospective cross-sectional research aimed to quantify structural variations of paranasal sinuses in individuals receiving CT scan examination. 210 participants took part in this research. The recruited patients' ages varied from 18 to 60 years, including 120 male and 90 female patients. A CT scan was conducted using a Bright Speed Elite-16 equipment manufactured by Wipro GE Health Care Private Limited, located in the Department of Radiology. Coronal sections imaging was directly performed on all patients. Axial scans parallel to the orbitomeatal line were conducted in rare instances with patients in the supine posture. All films were shot without contrast. No intravenous contrast was administered. Morphometric assessments were conducted by assessing the regions of each tomographic slice by meticulous monitoring of the measuring functions of the CT scanner. We determined the volume of CT in each region by multiplying the area by the slice thickness. We used the Cavalieri principle to determine the total volume of regions by averaging the standard deviations of all slice volumes. The total volume was reported in cubic centimeters as the mean ± SD.

STATISTICAL ANALYSIS

The statistical evaluation was conducted using SPSS software version 22.0. The students t-test and Kruskal-Wallis test were used for statistical validation. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

Table 1 show that gender and age of the participants. Table 2 displays the morphometric analysis of CT imaging used to measure various dimensions of paranasal sinuses and closely associated structures. There was no significant variation in morphometric data between the left and right side.

Table 1 Gender and age of the participants

Gender	Number =210	Percentage	P value
Male	120	57.14	0.15
Female	90	42.86	
Age in years			0.16
Below 25	25	11.90	
25-35	96	45.71	
35-45	76	36.19	
Above 45	13	6.19	
Mean Age	36.54±3.54		

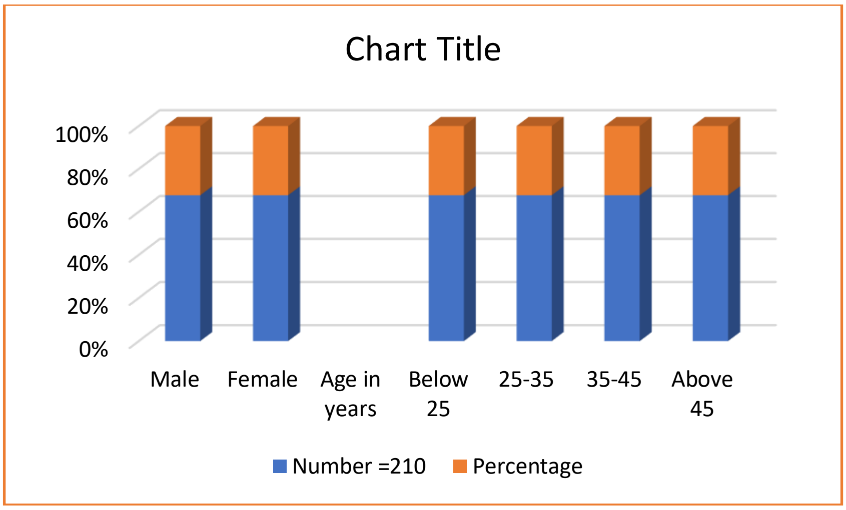

Figure 1: Gender and age of the participants

Table2:Morphometric measurements(cm)oftheparanasalsinuses

Sinus	Sides	Antero-posteriordistance		Cranio-caudaldistance		Transversedistance		pValue
		Mean	Sd	Mean	Sd	Mean	Sd	
Frontal	Right	1.53	0.15	4.94	0.34	5.42	0.84	0.07
	Left	1.41	0.19	4.71	0.44	4.82	0.65	
Maxillary	Right	5.03	0.78	4.91	0.87	2.91	0.46	0.25
	Left	4.53	0.89	5.26	0.54	2.12	0.19	
Ethmoid	Right	2.23	0.23	2.55	0.59	1.94	0.33	0.33
	Left	2.03	0.54	1.93	0.23	1.32	0.26	
Sphenoid	Right	2.82	0.78	1.72	0.27	1.53	0.29	0.16
	Left	3.24	0.56	2.82	0.22	2.45	0.58	

The mean volumes of the frontal sinus, maxillary sinus, ethmoid sinus, and sphenoid sinus were 8.41±1.34 cm3, 19.01±2.46 cm3, 7.34±1.04 cm3, and 7.11±1.21 cm3, respectively. There was a statistically significant difference in the volumes of paranasal sinuses across genders (P<0.05). The average capacity of paranasal sinuses in older persons gradually decreases. Table 3

Table3:Theaverageofvolumes(cm^3)offourparanasalsinuses.

	Mean	Sd
FrontalSinus	8.41	1.34
MaxillarySinus	19.01	2.46
EthmoidSinus	7.34	1.04
SphenoidSinus	7.11	1.21

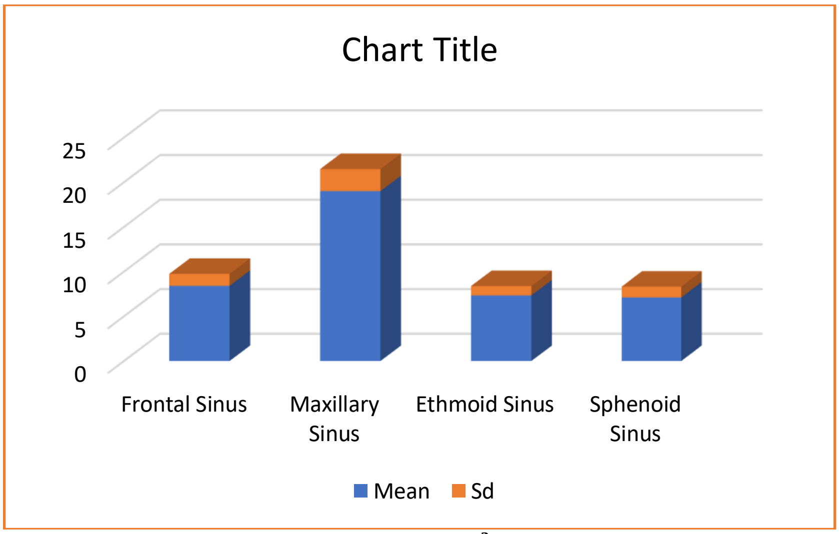

Figure 2: Theaverageofvolumes(cm^3)offourparanasalsinuses

Analysis of the capacity of paranasal sinuses revealed a significant variation between genders ($P < 0.05$) as indicated in Table 4.

Table4:Theaverageofvolumes(cm^3)offourparanasalsinuses

Gender	FrontalSinus		MaxillarySinus		EthmoidSinus		SphenoidSinus		P value
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	
Male	8.99	1.02	22.77	2.15	8.76	1.07	8.45	0.98	0.03
Female	6.31	0.89	18.87	2.32	6.12	1.01	6.76	0.89	

Female patients had paranasal sinuses with volumes that were 20% less than those of male patients

Table5:Theaverageofvolumes(cm^3)oftheparanasal airsinusesaccordingtogender

Sinus	Sides	Male		Female		pValue
		Mean	Sd	Mean	Sd	
Frontal	Right	15.12	2.23	11.29	1.76	0.16
	Left	16,04	2.34	11.66	1.98	
Maxillary	Right	31.12	3.43	22.85	2.46	0.06
	Left	20.01	2.65	15.65	2.32	
Ethmoid	Right	9.78	2.37	7.52	1.45	0.31
	Left	8.61	1.24	7.99	1.43	
Sphenoid	Right	9.83	2.05	8.11	1.76	0.007
	Left	9.74	2.09	7.56	1.45	

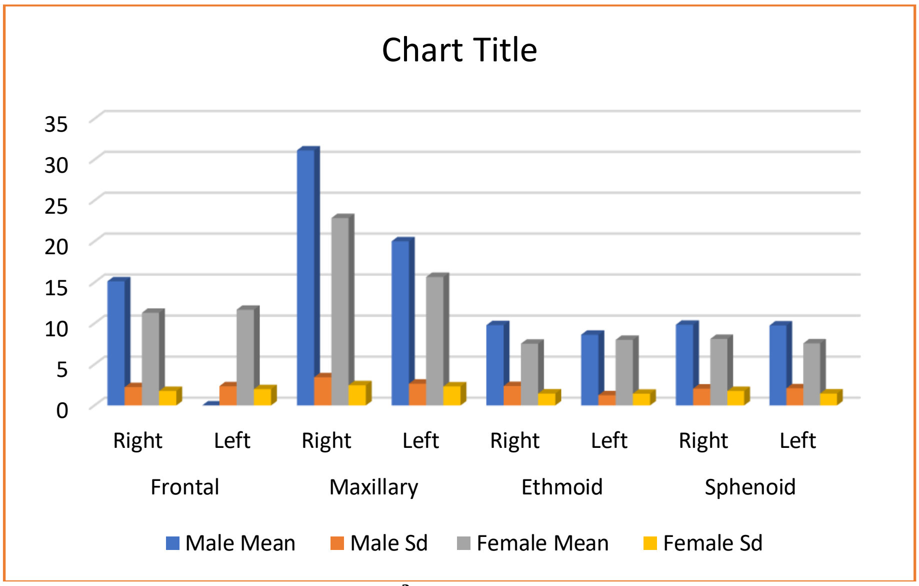

Figure 3: Theaverageofvolumes(cm^3)oftheparanasal airsinusesaccordingtogender

The independent Student t-test revealed a statistically significant difference in the average volumes of paranasal sinuses between men and females, with males showing more prominent volumes. Male patients had considerably larger average volumes of the right-sided sinuses compared to female patients, as seen in Table 5.

Table6:Theaverageofvolumes(cm^3)oftheparanasal airsinuses accordingtoage

		Age								
Sinus	Sides	Below 25		25-35		35-45		Above 45		pValue
		Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	
Frontal	Right	15.32	1.43	11.67	1.15	12.48	1.32	10.87	1.34	0.13
	Left	17.02	2.32	12.02	1.22	13.21	1.18	10.58	1.18	
Maxillary	Right	32.16	3.18	25.89	2.65	22.23	2.43	21.26	2.65	0.03
	Left	30.04	3.22	23.65	2.87	21.54	2.87	21.94	2.67	
Ethmoid	Right	9.79	1.45	6.54	0.78	6.93	1.15	6.12	1.03	0.12
	Left	8.96	1.52	6.03	0.98	6.96	1.15	5.97	0.32	
Sphenoid	Right	9.48	1.43	7.52	1.16	8.45	1.04	6.42	2.13	0.05
	Left	8.99	1.54	7.12	1.33	7.99	0.98	6.21	2.13	

The mean volumes of the paranasal sinuses were compared across various age groups of individuals from both genders. This study verified that the volume expansion of the paranasal sinuses had an inverse correlation with different age groups. The sinuses had symmetrical right and left sides. Below the age of 25, there is a progressive decline in the volume of the paranasal sinuses as the patient gets older. Table 6.

Table7:Theaverageofvolumes(cm^3)oftheparanasalairsinusesaccordingtothetypeofDeviatedNasalSeptum(DNS)

TypeofDeviatednasalseptum	FrontalSinus		MaxillarySinus		EthmoidSinus		SphenoidSinus	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
Straightnasalseptum	19.01	2.76	20.15	2.43	19.27	2.32	16.84	1.76
Right-sidedDNS	17.54	2.23	19.21	2.15	17.04	2.17	16.18	1.32
Left-sidedDNS	16.80	1.87	17.30	1.45	18.48	2.17	15.87	1.22

Patients with a straight nasal septum did not exhibit any statistically significant change in paranasal sinus volumes. The deviated nasal septum affected the size of certain paranasal sinuses. A statistically significant correlation has been shown in our investigation between the average volumes of paranasal sinuses and the existence of deviated nasal septum. Both right-sided (p=0.12) and left-sided (p=0.14) aberrations were observed. Table 7.

DISCUSSION

Precise measurements of the typical size and volume of the paranasal sinuses may serve as a diagnostic tool for identifying anatomical characteristics. This study is essential for assessing the anatomical characteristics of the paranasal sinuses, which may provide vital information and recommendations for surgeons and researchers [13]. We conducted morphometric analysis utilizing CT scans from patients of various age groups in our research. We statistically determined the diameters of several paranasal sinuses and associated structures. There was no substantial disparity in morphometric data between the left and right sides of certain sinuses. Researchers used several methodologies and imaging techniques to conduct volumetric investigations of paranasal sinuses, as shown in references [13-16]. However, few studies took into account the distances between sinus walls and computed sinus volume by creating a geometrical model of the sinuses. Recent research have shown that the Cavalieri principle may be used to determine three-dimensional volume by analyzing two-dimensional data from imaging investigations [16,17].

The paranasal sinuses consist of four minor sinuses: frontal, maxillary, ethmoidal, and sphenoidal. Understanding the various volumes of paranasal sinuses is crucial for promptly diagnosing, planning therapy, and monitoring conditions including allergies, hypoplasia, and infections in the sinonasal area. Understanding the paranasal sinus volumes and anatomical characteristics of the sinuses is necessary for performing effective endoscopic sinus surgery [14-17].

The Cavalieri principle is more dependable than the ellipsoid approach, but it is also more time-consuming [16,17]. According to the Cavalieri principle, volume measurements may be easily obtained from a conventional CT scan. Hence, it is appropriate for everyday clinical use [13]. The current research used CT scanning technology in conjunction with the Cavalieri concept of stereological approaches. The research study provided the average volumes of the frontal sinus, maxillary sinus, ethmoid sinus, and sphenoid sinus. There was a statistically significant difference in the volumes of paranasal sinuses across genders ($P < 0.05$). Our results indicate a steady reduction in the volume of paranasal sinuses in aged persons. There was a notable disparity in paranasal sinus volumes between male and female individuals ($P < 0.05$). 20% of the female patients were examined and were smaller than the male patients. Our findings align with previous studies indicating that paranasal sinus volumes were greater in men than females, but decreased with age progression [18-21].

We also compared the morphometric measurements and analyzed the volumes of the paranasal sinuses in various age groups. The study verified that the volume of the paranasal sinuses had an inverse correlation with age groups, and that the right and left sides were symmetrical. The deviated nasal septum affected the size of certain paranasal sinuses.

Studying the size and shape of the paranasal sinuses in individuals of various age groups helps identify actual pathogenic changes and aids in treatment planning. Enhancing the reliability of our research might be achieved by using a bigger sample size and analyzing the development pattern of paranasal sinuses.

CONCLUSION

We concluded that the computed tomography is a dependable technique for assessing various morphometric measurements and volumetric analysis of paranasal sinuses. It is crucial to be aware of the normal volume limitations of paranasal sinuses in persons with considerable variances in order to address various pathological disorders effectively. Thus, using the Cavalieri principle for assessment is a beneficial approach to measuring paranasal sinus volumes derived from computed tomographic images.

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